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## A LECTURE

ON

# EFFECTS OF WEATHER

ON

## INSECTS,

DELIVERED AT THE

Royal Agricultural College, Cirencester.

BY

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## EFFECTS OF WEATHER ON INSECTS.

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THE following Lecture on the effects of weather (such as rain, frost, heat, or drought) on insect-life, and methods by which these influences may be brought to bear practically in the course of common agricultural treatment on diminishing the amount of insects injurious to our crops, was delivered to the students of the Royal Agricultural College, Cirencester, by Miss E. A. Ormerod, on Thursday, October 12th.

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A few years ago the subject of how far knowledge of weather influence could be reliably and serviceably used in connection with the management of Forest and Food Crops was brought forward by the Meteorological Congress at Vienna under the name of "Agricultural and Forest Meteorology," and in the United States of America the subject has received for some time (and is now receiving), practical attention in its bearings both as to direct and indirect effect on insect-life.

Our own Meteorological Society has also given some amount of attention to the same subject, and, by search through our Agricultural Reports, and especially those given yearly in terse tabulated form, which may be conveniently studied with coincident weather reports, we may see clearly that great appearances of our crop pests often occur, either accompanying, or after, or after some unusual duration of, some particular state of weather. But as yet, although some points are clearly

known, we need many more observations, both carefully made and carefully recorded in full details; and still more, we need considerations as to how, though we cannot alter the weather, we may modify its effects.

At present weather-influence is commonly spoken of as if the weather—that is, cold or heat, drought or rainfall—acted in just the same way on all kinds of insects, and also on insects in all their different stages of life, whereas this is very far from being the case. The Golden Chafer, or the Turnip Flea-beetle, thrive in hot summer sunshine, whilst the Daddy Longlegs or Crane Fly likes the cool dampness of overshadowed meadow grass; and again, what one species of insect thrives on in its fully-developed state may be precisely what would not have suited it as a caterpillar or grub.

Also we need to distinguish more exactly what is meant by the word “weather,” for difference in amount of heat or cold act very differently, according to the amount of rainfall or of moisture accompanying them. Many grubs, such as are called “surface caterpillars,” will stand severe cold as long as they are in their own specially-constructed wintering places, but if thrown out, so that they are exposed to wet also, they die. A sudden downfall of cold rain will clear off caterpillars in summer; or again, with regard to some kinds of eggs, though heavy rain may destroy them, yet they will not hatch as well in heat and drought as when there is a certain amount of moisture in the air.

Insect-life is also affected, not only by the state of the weather at the time being, or shortly before any given time, but the effects of weather may be traced for one or for two years or more, sometimes directly in the conditions of the insects themselves, sometimes by promoting the growth of special weeds (Charlock for example) which may be the food-plants of some special crop pest, and also by so affecting the state of the ground that regular measures of cultivation, by which plant and insect vermin are usually cleared out, cannot be carried on.

If we now consider the condition of our common farm insects during autumn and winter, the time when we are commencing the farming operations for the next season, we shall see some of the reasons why they are uninjured even by severe cold.

The winter-state, which we call "hybernation," is not simply a torpidity caused by cold, for we find that in cases where the regular time for hybernation was not arrived insects have carried on their occupations quite undisturbed by a drop in the temperature of some degrees lower than the warmth of some weeks later, when they were retiring in due course to their winter quarters.

Kirby and Spence give an instance in which for a week preceding the 14th of October (on which day great numbers of insects were noticed seeking hybernating spots) the temperature was never lower than 48° at night, and on that day was 58° in the shade; whilst on the 31st of the preceding August the greatest heat of the day was not more than 52°, thus showing a difference of six degrees more warmth even in the shade at the time of hybernation than six weeks earlier, when the seasonal or periodic influence was not acting.

Hybernation appears to be quite a distinct condition from mere effect of cold; rather a constitutional *seasonal* influence in which insects, whilst they have still all their instinctive faculties in good order, prepare a shelter for the time of coming cold and want of food. They do not just pass into a state of torpor indifferently wherever they may be, but select some special locality under leaves or stones, or some safe protection; or form a cell, or in some way supply themselves with shelter, and there they—or such of them as hybernate—pass into a quiet, motionless state, the animal functions decreasing in power with the increase of the cold; but still, even if totally frozen so that they can be broken like sticks, many kinds of caterpillars are not injured, so long as the freezing takes place in the shelters they have made for themselves.

We find that the surface caterpillars, which we have seen feeding at the roots of Turnips, Beet, or other crops during the summer, do not lie about haphazard during the winter, but before the time comes for their torpid state (or for the change to the chrysalid stage, in which some pass the winter season) they form for themselves cells or hollow oval chambers, more or less smoothed on the inner surface, a little below ground.

The caterpillar of the common Heart and Dart Moth (*Noctua (Agrotis) exclamationis*), which will feed almost on any field or garden crop, turns to chrysalis during September or October in an earth-cell three or four inches below the surface; the Cabbage Moth (*Mamestra Brassicæ*) caterpillar also for the most part goes into chrysalis similarly beneath the surface; the Turnip Moth (*Noctua (Agrotis) segetum*) lives in caterpillar-state below the surface, either feeding out of reach of hard frost or coiled up in a cell formed for itself in a ball of earth; and the caterpillar of the Great Yellow Underwing Moth (*Tryphæna pronuba*), which feeds sometimes on Turnips, and is stated also to be destructive to grass roots, although, like the Turnip-grub, it feeds (weather permitting) during winter, yet secures itself from over-exposure, and when it goes into chrysalis, in the spring, it is in an earth-cell.

Now in these earth-cells, in which many kinds of *larvæ* (caterpillars, grubs, or whatever we may like to call them) pass the winter, they are protected from drying winds and from sudden changes of temperature; the smoothed inner surface keeps an unchanged atmosphere round them, and also appears to exclude wet, so that the caterpillar lies clean and dry within, without risk of its breathing-pores being choked by mud, which, though not possibly of importance to it whilst torpid, is a very serious matter when it wakes from its winter sleep.

Both caterpillars and chrysalids vary in the amount of cold they can endure. The caterpillar of the Yellow Underwing Moth will bear being frozen into a ball of ice

without injury, and the chrysalid of the Large Cabbage Butterfly will develop properly after being exposed to a temperature of zero.

Without, however, going into too minute details of the various experiments that have been recorded from the time of Réaumur onwards, it appears that these common farm-pests will survive, so long as they are in their own cells, a greater amount of cold than they will be exposed to, even if the temperature sank on the surface of the ground to zero for a much longer time than is likely to occur in the greater part of these islands.

If they are *not* in their own cells circumstances will affect them very differently, for we find that with many of our caterpillars and chrysalids it is not the effect of cold alone that destroys them, but if (by ploughing, digging, or any other operations) we can throw them out of their cells, or other defences they have prepared for their winter habitations, and thus scatter them, mix them with the soil and expose them to drying winds, to alternate freezing and thawing, or lying soddening in the rain, or wet ground, when too torpid to move, that thus we get rid of great numbers.

To put this in other words, as brought forward in one of the Reports of the State Entomologist of Illinois:— “It is evident that freezing does not injure the ‘cut-worms’ (as what we call surface-caterpillars are there described), for Nature has prepared them for it, . . . . but freezing in connection with loose wet soil, and this will kill the chrysalids as quickly as it will the worm or caterpillar.”

There are many other crop-attacks which may be checked by following up the same principle of disturbing the customary winter arrangements of the insect, and taking advantage of the short season in which winter torpidity throws these troubles of the summer into our power. Thus in the case of the maggots and pupæ of some kinds of the Diptera (or two-winged flies) we may throw them on the surface, or turn them down so deeply in autumn cultivation that any flies that may develop

will have no power to work their way through the quantity of earth above them ; and the best known remedy for the Wheat Midge is the method in which this plan is carried out in Canada and the United States of America. This is, when the "Red Maggot" is lying at the bottom of the stubble or a little below the surface in autumn, to skim off with the first turn-furrow of the plough about two inches of the surface-soil, with all the stubble, weeds, and vermin in it, and turn it to the bottom of the furrow ; then raise another slice with the second turn-furrow, and, throwing it over the first, bury it some inches deep. By this means the pest may be got rid of, if the surface can be left undisturbed until after the natural time of development for the Wheat Midge in the following season has passed, for even if these gnat-like flies develop, their delicate powers are quite unsuited for piercing through the firm ground above them, and consequently they perish. It is, however, necessary that the ground should not be turned up again too soon, or the chrysalids or maggots in their cases may develop, and we shall have no benefit from their temporary burial.

I do not know the reason of the prolonged powers of life in some kinds of fly-maggots in circumstances which one might expect would kill them, but it may be conjectured to be from their small amount of breathing apparatus. They have for the most part only two spiracles or breathing-pores, and in the case of the Daddy Longlegs (*Tipula*) grub, we know that they will bear at least fifty-eight hours' total immersion without being either drowned or suffocated.

In the next stage the embryo of many kinds of the two-winged flies may gain more protection from the pupa-case being formed of the hardened skin of the maggot, than what is afforded to moth or butterfly caterpillars by the mere hardened film of exuded gummy matter with which they are covered.

Many of the fly-maggots (such as onion or cabbage maggots), when about to change to pupæ, merely

contract, the outer skin hardening into a somewhat oval case, in which the future fly develops, and from which it presently escapes by cracking it open. Thus the fly may be said to carry its case or shelter along with it, and if these "barrel-pupæ," as some of them are called in Germany, are brought up again to the surface in spring, they are likely to be little the worse for all we have done to destroy them, whilst, if left undisturbed, or, as may be easily managed in garden ground, a crop which only requires surface-cultivation put above them till the time for their development is past, we shall probably get rid of them all.

Thus, that is by throwing the caterpillars and chrysalids from their prepared shelters, we may also lessen the amount of coming attack from many kinds of sawflies and beetles. In the case of sawflies, the cocoons may be thrown out in scores from under gooseberry-bushes ; in masses as large as a man's fist from under the pine-trees they have infested in autumn ; and, in the case of beetle larvæ or chrysalids, we may get rid of some very injurious ones in this way ; but the Wireworm, having the instinct to bury itself when the weather is too cold for feeding, can only occasionally be dealt with in a torpid state ; and the Cockchafer-grubs, which are a great pest, also bury themselves safely too deep to be easily reached.

Thus also we may very much lessen the numbers of some of what we may call our regular field-pests, such as Turnip Flea-beetle, Mustard Beetle, and others which pass the winter in the fully-developed state under clods of earth, stones, or rubbish, or dead bark, or at the roots, or even down the hollow stalks of stubble or reeds. For the most part we know where they are likely to be, and can apply the remedies accordingly, amongst which burning, whether of rubbish collected on the field, or of such matters as may shelter insect vermin around it, or (where it can be safely done) firing the dry plant on the surface, is one that is exceedingly serviceable, but in case it is not certainly known where the insect passes

the winter, it is well to gain reliable information on this point before beginning operations.

It may seem almost idle to offer such a suggestion, but sometimes great expense is gone to in applying what are known to be insect-deterrants, but which fail in their effect because no insect is there to be acted on; and the landholder not only loses by the unprofitable outlay, but is discouraged from further trial.

*Eggs.*—The effect of weather as a means of destroying insect-eggs appears to depend on their being exposed to weather influences of a different kind to those they were prepared for by the arrangements of the parent insects, or by their own special constitutions. Thus in the case of the *Aletia argillacea*—the moth of which the eggs produce the well-known cotton caterpillars of the United States—we are told that these eggs are laid during the summer beneath the leaves, or exceptionally on the leaves, or on any exposed part of the plant, but “all eggs perish which are unhatched when overtaken by frost.”—(Cotton-worm Bulletin, p. 10).

Some eggs are destroyed by heavy rain, but the weather influence, that seems mainly to be depended on as an agent, we can fairly bring to bear in agricultural practice, is *desiccation*, that is, drying the egg by throwing it out from its natural locality to such influence of air and sunshine as may dry up the contained fluid, and thus prevent the embryo within from developing.

In many cases the egg, whether laid singly or in clusters, is so placed as to be protected from rapid drying or sudden changes of temperature. This locality is often either a little below the surface of the ground, as with one or more of the Onion Flies, the Carrot Fly, Cabbage-root Flies, and others, or amongst damp herbage, or on, or close to, the plants at the ground level, as with the Daddy Longlegs or the Click Beetle (from whose eggs we are infested with the Wireworm); and many moths lay similarly. Some eggs, as of the Turnip Flea-beetle, the Beet Fly, and the Large Cabbage Butterfly, are laid on the under side of the leaves, and

others, which are deposited on twigs or bark, may be found protected by a peculiar cement-like coating, or by down from the parent insect, or, in the case of the common Apple Scale, by the dead body of the female.

We know, from the often-quoted experiments of Spallanzani, that insect-eggs have been found to bear a four hours' exposure to a cold of  $38^{\circ}$  below zero of Fahrenheit without any apparent loss of vitality; and John Hunter found that, although eggs that he exposed to  $15^{\circ}$  were solidified, that they were not destroyed; and recently Mr. Buckton has given us a note of seeing a young Rose *Aphis* hatch out of its egg when the thermometer read at  $25^{\circ}$ . From this it does not appear as if we could depend on cold to rid us of insect-eggs. I am not aware of any series of observations having been made as to the development of the eggs of our crop-insects, but from the enormous amount of details that have been published regarding Locusts by the Board of Agriculture of the American Government we may gain information of which the general principles may be of service to ourselves.

Firstly, it is laid down as essential to excessive amount of Locust presence that the parent insects should be healthy, and the eggs properly deposited. These eggs are laid in masses seldom more than an inch below the surface of the ground. It has been found, by experiments carried on in natural circumstances, that from the eggs buried two inches deep about a third of the young Locusts managed to make their way to the surface, but none from eggs placed at any greater depth. Down to a depth of twelve inches the eggs hatched, and the young larval Locusts worked their way for an inch or two through the earth, but they were not able to pierce their way entirely through it, and at the time that these were hatched, eggs which were more deeply buried were still unhatched. Instances were also noted where hatching being retarded by the eggs being placed at a still greater depth, they lay there uninjured, and on being brought to the surface hatched at once.

From this we see that it is possible to prevent attack by turning the eggs down to an ascertained depth, at which, although the tenant may hatch out, yet if the ground is in a natural state the insect cannot penetrate it. If the earth is cracked, of course the deep crevices admit air, and alter the state of the case.\*

The Locust egg will bear freezing and thawing and soddening in water, but the date of hatching, or rather the length of time between its deposit and the appearance of the young Locust out of it, has been found to vary according to the variations of temperature, from which it has been inferred that the egg requires a certain amount of heat to develop it, but that this amount may be equally healthily conveyed by a short time of much warmth, or a longer time of cooler weather.

Eggs have hatched at localities in the Northern States where the maximum temperature during the spring had rarely risen to  $50^{\circ}$ , and never exceeded  $53^{\circ}$ ; and from the experiments carried on by different observers it appears that at a

Uniform temp. of  $85^{\circ}$ , the number of days required for hatching was 31.

„	„	$75^{\circ}$ ,	„	42.
„	„	$60^{\circ}$ ,	„	60.
„	„	$50^{\circ}$ ,	„	116.

From these experiments we have proof with regard to one kind of insect that the development of the embryo in the egg may be retarded or entirely checked for a time by states of temperature or situation, but yet that (within certain limits) the vital powers continue, and when the eggs are put in favourable circumstances the embryos within will develop, and the temporary chilling or burying will only have delayed (not saved us from) the appearance of the young

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\* This information is mainly taken from the Report of the Entomological Commission of the U.S.A. Government, 1877.

Locusts, and in this example of the possibility of eggs lying unhatched, but still safely buried, it seems to me that we may have a clue to the occasional appearance of some insect in a limited area where there was no obvious reason for its sudden appearance.

However this may be, it is plain that we can destroy great numbers of eggs by throwing them out, upwards or downwards, from their natural place of deposit, and also we may diminish the quantity of eggs laid above ground by diminishing the number of places proper for egg-laying.

The Daddy Longlegs Flies prefer damp grass for egg-laying ; some of our farm moths lay in the shelter of the large breadths of neglected weeds we see round fields and gardens, and by ordinary means we may clear many of these nurseries of coming attack away. Good liming is a means of keeping the Click Beetle from laying eggs to infest the meadow with Wireworm, and a better plan still is penning sheep, and feeding them on any grass that it is particularly desirable to protect, thus not only preventing oviposition, but, from the surface of the ground being sodden with matter injurious to insect-life, destroying the young grubs just beneath it.

With some of our cabbage-root maggots we find that the crop escapes much better where chemical manure, such as superphosphate, is applied than where farm manure or bone-dust is given. This is very likely, partly owing to the chemical constituents being, as we have been shown, more suitable for pushing on the very first growth than the ammoniacal manure ; but also I attribute it to the flies, like many other of the *Anthomyidæ*, preferring moist decaying matter for the deposit of their eggs, and therefore being attracted by putrescence.

There are some cases in which a slightly different method of cultivation from that usually practised would at once benefit the plant, and protect it from attack. The Onion Fly, or flies rather,—for the researches of Mr. Meade, in the course of this year, have shown us that

there are at least four distinct species,—lay their eggs very frequently either just below the surface of the ground, or, if possible, at the base of the bulb. I have found that if onion bulbs are earthed up from time to time the flies are thus obliged to lay their eggs haphazard, on the leaves or ground, or at least not in such a position that the maggots, if they hatch at all, can make their way to their food, and this prevents very much of the attack, and agrees well with the plant-growth.

*Larvæ.*—In this country the conditions which are most favourable for the hatching of the larvæ of the greater part of our insects are moderate warmth, together with some degree of moisture. We may see this from the larger proportion of eggs which hatch during the warm season of the year; but heavy rain, and especially rain following after a term of warm, dry weather, is most destructive to larvæ which are exposed to it, such as various kinds of caterpillars of moths, butterflies, and some kinds of sawflies. It is stated in 'Farm Insects' by John Curtis that most caterpillars are purged by wet, but that some (the caterpillars of the Large White Cabbage Butterfly, for instance) do not invariably suffer. Mention is made of caterpillars of this kind, which had grown rapidly during some hot dry days, being found on the afternoon succeeding a rainy night dead and empty, the lax skins merely containing some fluid. In the attack of the Silver Y Moth (*Plusia gamma*) in 1879, the ravages of the caterpillars were recorded as being checked at Maldon, in Essex, by the drenching rains; and in the case of the Silkworm, the bad effect of wet food to their caterpillars is well known to the growers. Some sawfly-caterpillars are similarly affected. Those of the Pine Sawfly are very susceptible of wet and cold, and, though the black caterpillars of the Turnip Sawfly will bear a shower, they are sometimes cleared in great numbers by the heavy down-pour of a thunderstorm; also it is stated that rains are singularly destructive to these caterpillars by

rendering the turnip-leaves very watery, which soon kills them.

We do not clearly know in what way sudden or violent rainfall acts on the larvæ ; after looking at all the observations accessible on the subject it appears to me to act in many obvious ways at once. The heavy rains fairly beat many of the caterpillars from the plants, and their moving and breathing apparatus are so clogged with wet and dirt, that some are suffocated and some cannot stir until all the supplies within are exhausted, and they are starved to death. We know also that unsuitable food acts immediately on larval life ; therefore it is likely that, if the caterpillars are suddenly presented with a diet changed by rain to watery sap, and also accompanied by water lying on the leaves, that they should suffer ; but it does not appear that this can be wholly the cause of the sudden sickness, for we do not hear of it (as far as I am aware) similarly affecting caterpillars feeding below ground, or in the hearts of the cabbage, unless they are fairly drowned out.

The peculiar arrangement of the breathing apparatus of insects renders some of the kinds very liable to being destroyed by any means, such as dust, mud, water, or other substance that may choke the pores. The operation of breathing is carried on by insects not by means of a mouth and lungs, but by means of small openings called spiracles (from the word *spiro*, to breathe), and for the most part arranged along the sides. Each spiracle forms the opening to a single air-tube or trachea, and from these branched tubes wander through every part of the insect, conveying air to the limbs, and also to act on the visceral fluid (commonly called blood) which fills the cavity of the body. In the perfect stage of the insect most of the air enters the insect through the air-pores in or near the thorax, and therefore the pinch beneath the wings, which we know to be a simple way of killing our specimens, is considered to do so by suffocation.

In the larval or chrysalid stage breathing is stated to

be carried on almost equally by all the spiracles. In the case of moth and butterfly caterpillars these air-pores are eighteen in number, and placed one on each side of the 1st segment behind the head, and of the 4th to the 11th segment inclusive; but in the case of two-winged flies the majority of the larvæ have only two spiracles, which are situated at the extremity of the body.

If, when the insects are in an active state, the spiracles or breathing-pores are choked by any means which prevent air entering the creature, it dies: how far it suffers from fluid in which it may be partially lying gaining entrance to the system through the tubes, we do not know, but practically the effects appear to be very injurious to such kinds as have many spiracles.

The exact method by which heavy or long-continued rainfall clears off insect pests by fields' full, which we have no other means of getting rid of, is an important practical matter, and we need to know much more about it relatively to the possibility of supplying ourselves artificially with a similar kind of remedy, and applying, on an extended scale, the methods now found serviceable in many gardens.

Year by year we see the recurrence of the same reports regarding various insects. The Turnip Fly, or Beet Fly, or whichever it may be, was very injurious till the rain washed it off, or started the plant, or in some way put an end to its ravages. Now, if we look at the great amount of injury we suffer from overplus of rain in some years and deficiency in others, it appears well worth consideration whether a more extended plan of field cisterns and drainage of water into them, both from fields and roofage, might not be of service. The average yield of water per year from a roof 15 ft. by 20 ft. (that is, a roof covering an area of ground of that measurement), from a mean rainfall of 25 in., is calculated at 3900 gallons. Deducting 20 per cent. for loss on a tiled roof, or 10 per cent. (which is above the amount lost) on a slated one, this would give a yield

respectively of 3120 or 3510 gallons; and, without at all venturing on a subject so far beyond me as the general utilisation of excessive rainfall, yet it may be safely stated there is many a homestead where the roofage yield of water is allowed to run to waste, which, with full allowance for the cost of properly-built and cemented cisterns, would soon yield a paying return if at hand in time of need in the fields.

Perhaps I should ask your pardon in thus apparently passing for an instant from the special considerations of to-day, but it is so plain that a better regulated distribution of water, both as an external application to clear off insect vermin and for absorption by the roots to press on the growth, would be thoroughly useful, that the point of how far it could be managed by steam-power at a paying rate is well worth thinking of.

We know, through Mr. Symons' returns, what is the rainfall of each district, and the cost of cisterns (or of field-ponds) can easily be known; and we see that there is a possibility of throwing water from the use of the fire-engines worked by steam, which are gradually superseding the hand-worked machines of other days. We see, too, every year—and on a vast scale in 1881—the enormous sums which are lost in dried-up districts, whilst in others, at the same period, precisely similar crops are saved by a timely rainfall destroying the insect-foe, or running on the crop; and, looking onward at the constant increase of special crops and the consequent increase of the special insects that feed on them, it appears an important matter to see how we may increase our powers of counteracting attack, by artificially using methods which in the natural course we observe are the most serviceable help we possess.

To return now to direct meteorological influences. We find that, as a rule, the development of insects through all their stages is periodic, that is, we find that the eggs are laid by each insect at a certain time, or at certain times, in the year; in some cases at certain times in the day. The larvæ usually hatch from these

at certain intervals from the date of egg-laying, and, after feeding for a known length of time, turn to chrysalids, from which the insect develops also at a known interval.

In the case of many of our double-brooded insects, the duration of the time of the whole series of changes is much less in summer than in winter, and usually (although not invariably) with regard to the insects of this country a certain amount of warmth and of moisture in the surrounding earth or air are the conditions most favourable for rapid and healthy development.

This progress, however, may be modified by a great many circumstances, such as temporary drought, or excess of wet, heat, or cold, and also by the effect which the condition of the plant-food, altered by these influences, exerts on the rapidity of growth, or the healthiness of development, and it is in a great degree in the fact of these various circumstances occasionally occurring in such succession as may suit the requirements of the insects in their successive stages that we find the explanation of the extraordinary appearances of insect-life that we occasionally suffer from ; whereas in the usual order of events they so influence one another that we are not devastated by one kind of insect, or the crops especially choked by one kind of weed. In American observation it is said that it takes at least two years to foster a great outbreak, and we may trace how a widespread attack is or may be produced by precise coincidence of suitable weather to the period of the different stages of the insect, from the notes given in 8th Report of the State Entomologist of Missouri regarding one of the greatest American insect-pests, the grass- and corn-feeding caterpillar known as the "Army Worm." This Northern Army Worm is the caterpillar of *Leucania impunctata*, Haw., a reddish-brown or fawn-coloured moth, about two inches in the spread of the wings, which is considered to lay its eggs mainly in old meadows or grass that has not

been pastured. If a temporary drought occurs there is an unusually large breadth of land made available for egg-laying by the partial drying-up of the swamps, and there the caterpillar can thrive and turn to chrysalis; but now, if wet returns and the swamps are unsuitable for the moths, they are driven out to infest the whole country. Whether this is really the case, and the cause of occasional bad attack, is a matter on which opinions differ, but any way the details give an example of how weather influence, changing with the changing needs of the insect, may increase its numbers.

The conditions of temperature and air in high altitudes are found to have marked effect on the development of some insects. It is recorded by Professor Riley that whilst injury from the Colorado Beetle reached up the Alleghany Mountains to a certain height above sea-level, that above that altitude the crops did not suffer. Bodies and eggs were found, but the eggs or the larvæ just hatched were dried up and dead, and it is considered that this destruction is owing to the dryness of the air joined to the cool nights.

Some valuable observations taken by Mr. H. Pryer in Japan relatively to the difference in size and colour of butterflies, which occur in connection with differences of temperature, have recently been published by the Entomological Society.\* These changes he states not to depend so much on the season of the appearance of the perfect insect as on the temperature that the larva has borne during its existence in this condition. The temperatures noted ran rather more to extremes than our own, as they are mentioned as frequently sinking as low as  $22^{\circ}$  or  $20^{\circ}$  in winter (or, as it is commonly said, to ten or twelve degrees of frost), and in summer frequently to rise to  $88^{\circ}$  or  $90^{\circ}$  in the shade.

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\* "On certain temperature forms of Japanese Butterflies," by H. Pryer, C.M.Z.S., Trans. of Ent. Soc. of London for 1882, part iii., pp. 485—491.

This affords us an excellent opportunity of learning effects of extreme temperature on some of our own common butterflies, which are also to be found in Japan, and if we select a few of these from the Japanese kinds mentioned we find first, that whilst the specimens which appear in March of the "Swallow-tail Butterfly," *Papilio Machaon*, are about  $2\frac{1}{2}$  to  $2\frac{3}{4}$  inches in the spread of the wings, and pale in colour, that the summer forms expand to about twice that extent, and are dark.

The "Pale-clouded Yellow Butterfly," *Colias Hyale*, is about  $1\frac{3}{4}$  inch in expanse, whilst a large summer specimen will measure  $2\frac{1}{2}$  inches; and the "Small Cabbage White," *Pieris Rapæ* (which, it is noted, does not differ either in its larval or pupal state, or its food-plant from our own kind), is small and light-coloured when it appears in March, whilst the later broods are larger, and the female darkly coloured at the base of the wings. A circumstance is also noted with regard to this kind which points very strongly to these differences being the direct effect of temperature, and not merely a periodic or seasonal difference in the state of the insect. Mr. Pryer mentions even in July he has taken, at an altitude of 3000 feet up Fujisan, smaller specimens than those taken in March near Yokohama, which is only about 100 feet above the sea.

In the case of another kind, *Papilio Maacki*, of which the early form is usually small and bright, and the summer one larger and darker, Mr. Pryer secured both forms in one day in June, the large form being abundant at 2000 feet altitude, and the smaller or cold-temperature form being equally abundant 1500 feet higher yet up the mountains.

I have quoted at some length from Mr. Pryer's long and useful paper, because the subject is not only of practical interest, but also because, whilst so much is said, as at present, regarding alterations of species, it is of importance to see how temporary circumstances

(in cases that we know to have been carefully observed and recorded) have been found so to affect the colour and size of the insects then in their first stages, that in their perfect state these different forms have been considered as distinct species, the difference all the while being merely (as far as shown by the large number of observations taken) in unimportant respects.

There are also differences in the colouring of some insects in coincidence with their spread to more southerly regions from our own as well as in connection with altitude, but these time does not allow to enter on now.

We may see for our own practical purposes how warmth affects the development of insect-life from the familiar example of our Wood Ants, which on a sunny day will carry the pupæ up to the higher part of the nest, and leave them just under the protecting sticks and rubbish until the cooler part of the afternoon, when they are all taken down again and stored safely out of the way of chills; and, in the case of our cabbage chrysalids, we may use the knowledge that warmth is serviceable for their maturation at once by clearing them out of all the sheltered nooks which, by reason of this requirement, we know they will be found in.

The coolness and darkness of the night, or the bright sunshine, as distinguished from the cloudy light of many of our summer days, all have their effect on insect-life, some of which we can utilise, and some of which, although we cannot alter them, will benefit us, if we notice them, by preparing us for coming attack.

The common Cockchafer is quiet under the leafage in the heat of the day, and may then be shaken down and destroyed; and, though we do not often suffer from injury caused by the grub of this beetle to the amount to which it ravages in Germany, yet the extent to which it has destroyed young pine plantations near Salisbury in the two last years show that we need to keep it in check, lest it should rise to be as severe a pest as the

grubs of various kinds of Chafers are now proving in the Southern Island of New Zealand.

The Daddy Longlegs grubs come out at night to feed, or travel on the surface, and are then open to rolling or other measures of destruction ; some of our turnip and cabbage caterpillars are similarly open to attack at night, or in the dusk hours, and the great caterpillars of the Death's Head Moth, which sometimes do great harm to the leafage of the potato, are variable in their time of feeding, so that it is desirable for some one interested in the matter to ascertain the habits of the special caterpillars before setting destructive operations on foot.

The Click Beetle, the parent of the Wireworm, may be swept up in great numbers in the evening from grass ; and, on the other hand, the Turnip Flea-beetle rejoices in the sunshine, and then flies far and spreads rapidly.

It is points such as these that we need to know more of ; it is the province of the entomologist to give the name of the insect, and to know the precise history of its method, and place of existence ; but it is the province of the agriculturist to notice, in real practical and continuous observation, the various influences which act upon it, and, may I not add, when observed to make them known. It is a matter of great importance—it is nothing less than the daily bread of the nation, which, for want of attention, is being in many cases absolutely thrown to the insect- vermin, whilst the landholder is distressed for want of the crops which need not have been lost.

There is an enormous amount of solid practical information in the hands, or rather in the minds, of many agriculturists on many points bearing on insect-prevention, and if they could but be persuaded to believe how solidly valuable it is, and to impart it for publication without regard to whether they know the scientific name of the insect (which is of no consequence, as they can always be furnished with it), it is beyond believing how

we might advance in knowledge of means of saving our crops from depredation.

At present we know little compared to what we need to know of the influence of weather, but there is one principle that may be rested on: insects are suited to certain conditions; place them, and especially in their early stages when they are most in our power, in other conditions, and you are certain to diminish their numbers.

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